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VARIATION IN THE NUMBER OF SEEDS PER POD IN THE BROOM, CYTISUS SCOPARIUS

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WHILE at Wood's Holl in August, 1907, I collected about 100 pods each from a series of 23 bushes of the broom *Cytisus scoparius*. On a vacant lot not far from the Marine Biological Laboratory the plants were growing vigorously, completely covering the space with bushes, many of which were higher than a man's head, and with stalks about an inch in diameter at the base. The material was gathered for an investigation of the relationship between the number of ovules formed and the number of seeds developing per pod. But when the counting was taken up the determination of the number of aborted ovules proved so difficult that I feared the results would be untrustworthy and gave up the project. While working over the data I noticed that Pearson[1] has recorded a series of countings of broom from an English locality, and it has seemed worth while to compare the two lots of material.

Many biologists have held the opinion that changed conditions of life, such as may be supposed to prevail when a species is transferred from one habitat to another, imply an increase in variability. The theories concerning the reason for this phenomenon need not be discussed here. I think the general idea will be familiar to all. I think about the only attempts to determine quantitatively whether there is any increase in the variability of a species when introduced into a new habitat are two studies by Bumpus. He first considered the variability of the egg of the introduced sparrow[2] and concluded that it is decidedly more variable in the United States than in its native country. In judging Bumpus's data on the directly measurable characters by the standard deviation instead of the range of variation Pearson[3] concluded that the American egg is not more variable than the English but rather less so when a more representative English series is taken. It is quite impossible to determine from the color and shape appreciations whether Pearson's English or Bumpus's American series is the more variable, but it seems to me upon rereading Bumpus's paper that he makes a very good case for a greater variability in color and shape of the eggs of his American as compared with his English series. However, Pearson's suggestion of a possible change in the color of the egg must be remembered. Vernon[4] considers the American eggs more variable in shape and color.

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[1] Pearson, K., and others, *Phil. Trans. Roy. Soc. Lond.*, A, 197, 335, 1901.

[2] Bumpus, H. C., "The Variations and Mutations of the Introduced Sparrow," Biol. Lect. Mar. Biol. Lab. Wood's Holl, 1896–97, 1–15.

Bumpus's second attempt to secure data upon this question was with the introduced Littorina.[5] He found from an examination of three English and ten American series, each of about one thousand individuals, that the American shells are much more variable than those from the British Isles. Duncker[6] who has reworked the data to express the variability in terms of the standard deviation and theoretical instead of empirical range agrees with his conclusions.

The results reviewed above indicate that more data on this question are much needed. Although his conclusions were based upon somewhat unsatisfactory statistical methods Professor Bumpus deserves very large credit for his thoroughly pioneer attempts to solve some of the problems of evolution in the only way in which they can be solved—by the collection of pertinent quantitative data. The problem of variation is such a complex one and sources of error are so numerous that great stress is not to be laid upon the results of the examination of a single series of material, but all conclusions must be tested repeatedly and on widely dissimilar organisms. The present lot of broom deserves consideration in this connection.

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[3] Pearson, K., ''Variation in the Egg of the Sparrow,'' *Biometrika*, 1, 247–249, 1901.

[4] Vernon, H. M., ''Variation in Animals and Plants,'' New York, 1903.

[5] Bumpus, H. C., ''The Variations and Mutations of the Introduced Littorina,'' *Zool. Bull.*, 1, 247–259, 1898.

[6] Duncker, G., ''Bemerkung zu dem Aufsatz von H. C. Bumpus: The Variations and Mutations of the Introduced Littorina,'' *Biol. Centralbl.*, 18, 569–573, 1898.

Cytisus is a native of Europe which has been reported from several localities in the United States. Mr. Vinal N. Edwards writes me that he started the colony from which my collection was taken in 1887 when he set out forty small plants which he dug up on Naushorn Island. In 1898 it was all cut down level with the ground when it came up thicker than ever. He thinks it was first planted on Naushorn Island some fifty years ago.

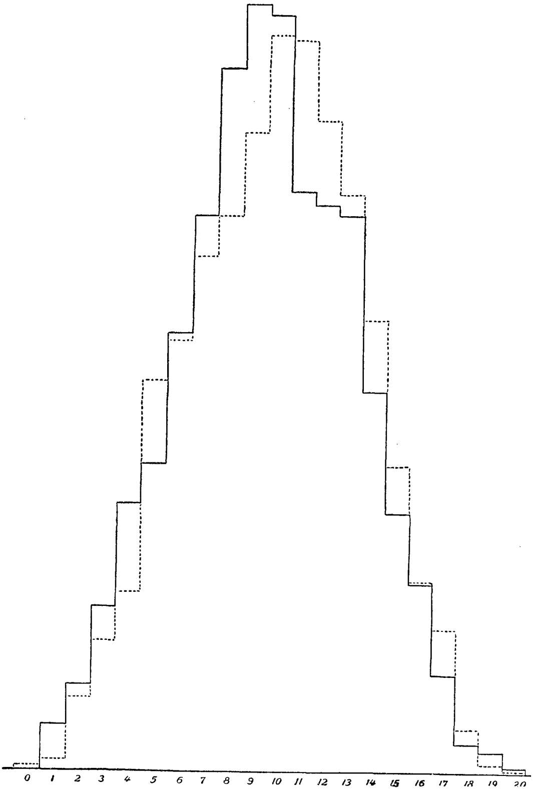
It seems hardly worth while to look farther for the ultimate origin of the colony since we have only a single series of European data for comparison. Several years ago Pearson collected ten pods each from a series of 120 plants at Danby Dale. To render his series readily comparable with my own I have multiplied his frequencies by

TABLE I

VARIATION IN NUMBER OF SEEDS OF BROOM

Seeds per Pod.	Danby Dale, England.	Wood's Holl, Mass.	Difference.
0	—	2	— 2
1	15	4	11
2	28	24	4
3	54	43	11
4	88	59	29
5	101	129	—28
6	144	142	2
7	183	170	13
8	235	183	52
9	254	213	41
10	250	244	6
11	192	242	—50
12	186	216	—30
13	183	190	— 7
14	125	149	—24
15	89	101	—12
16	61	63	— 2
17	32	47	—15
18	9	14	— 5
19	7	3	4
20	2	1	1
Totals	2,239	2,239	

the ratio 2,239/1,200 and placed them beside mine in Table I. The character of the pods is also shown graphically in the diagram where the solid lines represent the English and the dotted lines the American pods.



I think these polygons agree remarkably well. The empirical range is essentially identical. In both cases the highest class is 20. Pearson found no pods with an entire absence of seeds in the 1,200 which he examined, though he suggests that such may exist; I found 2 in the 2,239 of my lot. At first the differences between the frequency of pods in the individual classes, as shown in the fourth column of the table, and graphically in the diagram, seem rather large. But we must remember that two series of countings from the same individual would show many chance differences in their frequencies, and that neither of the series with which we are dealing is large enough to give very trustworthy results for the frequency of individual grades. We might avoid to some extent the difficulties introduced by the errors of random sampling by graduating the observed frequencies by some satisfactory fitting formula, but it does not seem profitable to take up the labor of curve fitting on the available data. We may, however, calculate the means and variabilities with their probable errors. The constants and their differences appear in Table II.

The means show that the Wood's Holl plants have about three tenths of a seed more per pod than the Danby Dale series. This is to be expected from the diagram where the polygon for the American series is seen to lie a little further to the right than the English. But the difference is only about four times its probable error and so only doubtfully significant even for the samples in hand. I think no one can examine these results and not be convinced that so far as is shown by the physical constants the two collections, one gathered in England and the other in America and counted and reduced by independent observers, are practically identical when we have regard to the probable errors of random sampling. And this notwithstanding the fact that the age of the plants, the number of plants involved, the ancestry of the individuals, and the climatic and soil conditions under which they grew are not taken into consideration or allowed for in any degree! If the constants were based on some character which the qualitative biologist would guess to be little influenced by the environment one might not be surprised at their close agreement; but we are dealing with

TABLE II

COMPARISON OF STATISTICAL CONSTANTS OF BROOM

	Average and Probable Error.	Standard Deviation and Probable Error.	Coefficient of Variation.
Danby Dale	9.6425±.0691	3.5466±.0488	36.780
Wood's Holl	9.9982±.0502	3.5236±.0355	35.242
Difference	—.3557±.0854	—.0230±.0603	—1.538

a character dependent not merely upon the internal and external factors determining the form of all plant organs, but upon the environmental factors influencing the chances for fertilization as well. Furthermore, it may be noted that we are dealing not with a little variable character, but with one having a coefficient of variation of about thirty five per cent. This is about two or more times the value of the coefficient of variation of the ordinary vegetative characters of plants, but not an extraordinarily high value for seed numbers, as determined from large series of unpublished data.

Summarizing the results of this note, I think we may say that so far as is shown by this one series of material Cytisus is no more variable in the habitat to which it has been very recently introduced than it is in one of its native habitats. As a matter of fact it is slightly, though not significantly, less variable at Wood's Holl than at Danby Dale. Possibly the sensible identity of the variability of the two samples may be due to the small number of individuals which furnished my series of data. These in their turn were probably derived from very few ancestors. I attach no great importance to the results. They simply show that so far as the present material is concerned there is no evidence in favor of the theory that the introduction of a species into a new habitat increases its variability. Possibly some other character than number of seeds per pod would have shown an increased variablity. I use this character merely because I had the data on hand as a by-product of some other work and felt that it would be better to let it contribute its bit of evidence on this problem than to throw it away. Possibly as a fellow biologist remarked when I showed him the closeness of agreement of the constants from the two series the result is "purely accidental." There are many possibilities of error in work of this kind. But until we have a large number of series of quantitative data it will be quite impossible to say whether or not there is anything of value in the theory of an increased variability of "introduced species."